

REPORT DOCUMENTATION PAGE

AFRL-SR-BL-TR-98-

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0182), Washington, DC 20503.

0380

thoring
tion of
y, Suite

| | | | |
|---|---|---|----------------------------------|
| 1. AGENCY USE ONLY (Leave Blank) | 2. REPORT DATE 13 Apr 98 | 3. REPORT TYPE AND DATES COVERED Final (01 Sep 94 - 31 Aug 97) | |
| 4. TITLE AND SUBTITLE Analytical Modeling of High Rate Processes | | 5. FUNDING NUMBERS F49620-94-1-0418 | |
| 6. AUTHORS Professor S.E. Jones | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Alabama, Department of Aerospace Engineering & Mechanics Tuscaloosa, AL 35487 | | 8. PERFORMING ORGANIZATION REPORT NUMBER | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFOSR/NM 110 Duncan Avenue, Room B-115 Bolling Air Force Base, DC 20332-8080 | | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER | |
| 11. SUPPLEMENTARY NOTES | | | |
| 12a. DISTRIBUTION AVAILABILITY STATEMENT Approved for Public Release | | 12b. DISTRIBUTION CODE | |
| 13. ABSTRACT (Maximum 200 words) Research was undertaken to deduce the mechanical properties of materials that are not usually candidates for Taylor test analysis. The Taylor test is a very promising method for acquiring data in the $10^4 - 10^6$ /sec. Strain-rate regime. It may be the only for deducing the state of stress for these strain-rates, if high strains are required. The Taylor test is usually performed for ductile metals for which there is a recovered specimen and elastic unloading is insignificant. However, many of the materials that presently interest the Air Force are not of this nature. Polymers are not of this nature. They have large elastic strains and the recovered specimen is usually of no value in determining the states of stress that the specimen has experienced during the deformation process. This is also true of some energetic materials. The mechanical behavior of energetics is of paramount importance to the Air Force's Hard Target Penetrator designers. In order to accomplish their objective, the computational mechanics group requires the mechanical behavior of energetic materials in a regime of strain-rates that are consistent with impact and penetration events. This leads us to the direction that the work supported by AFOSR has taken. | | | |
| 14. SUBJECT TERMS Taylor test, ductile metals | | 15. NUMBER OF PAGES | |
| | | 16. PRICE CODE | |
| 17. SECURITY CLASSIFICATION OF REPORT Unclassified | 18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified | 19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified | 20. LIMITATION OF ABSTRACT UL |

19980430 121

DTIC QUALITY INSPECTED 3

24 APR 1998



OFFICE OF THE DIRECTOR
FOR SPONSORED PROGRAMS

THE UNIVERSITY OF ALABAMA

94-1-0418

April 13, 1998

TO: AFOSR/NM
ATTN: ASSERT Program
110 Duncan Avenue, Room B115
Bolling Air Force Base, DC 20332-8050

FROM: S. E. Jones, University Research Professor
Department of Aerospace Engineering and Mechanics
University of Alabama

SUBJECT: Final Report for August, 1994-August 1997
ASSERT Augmentation Grant Supporting
"Analytical Modeling of High Rate Processes"

BACKGROUND

The ASSERT grant was given to the University of Alabama to support an Eglin Air Force Base sponsored effort in the area of characterization of materials under high loading rates. The parent contract for the ASSERT grant extended from 1993 until 1996. A new contract was issued in 1996 and extends until 1999.

Research was undertaken
~~I was tasked~~ to deduce the mechanical properties of materials that are not usually candidates for Taylor test analysis. The Taylor test is a very promising method for acquiring data in the $10^4 - 10^6$ /sec. strain-rate regime. It may be the only method for deducing the state of stress for these strain-rates, if high strains are required. The Taylor test is usually performed for ductile metals for which there is a recovered specimen and elastic unloading is insignificant. However, many of the materials that presently interest the Air Force are not of this nature. Polymers are not of this nature. They have large elastic strains and the recovered specimen is usually of no value in determining the states of stress that the specimen has experienced during the deformation process. This is also true of some energetic materials. The mechanical behavior of energetics is of paramount importance to the Air Force's Hard Target Penetrator designers. In order to accomplish their objective, the computational mechanics group requires the mechanical behavior of energetic materials in a regime of strain-rates that are consistent with impact and penetration events. This leads us to the direction that the work supported by AFOSR has taken.

G60 ROSE ADMINISTRATION BUILDING / BOX 870104 / TUSCALOOSA, ALABAMA 35487-0104
TELEPHONE (205) 348-5152 TELECOPIER (205) 348-8882

Equal Opportunity in Education and Employment

ACTIVITIES

To accomplish our objectives, we have replaced the conventional Taylor specimen with a film record of its behavior during the impact and subsequent deformation. We have been very successful in analyzing these film records for metals and it is natural to extend these efforts to the characterization of unconventional materials.

The first graduate student supported on this project, Mr. Sandor Augustus, worked on the development of a new theory for estimating the state of stress from post-test measurements of Taylor specimens. His work laid the foundation for the work that follows today. Mr. Augustus carefully evaluated the effect of specimen geometry on the key parameters of the mathematical model in order to validate the hypotheses behind the modeling effort. In this he was successful. A copy of his thesis, dated August, 1996, is attached to this report. He received a masters degree in Engineering Science and Mechanics in May, 1996.

My second student, Mr. Jeffrey A. Drinkard, started work toward a masters degree in Mechanical Engineering, with specific emphasis on impact testing of materials, in the summer of 1996. Mr. Drinkard spent about a month at Eglin AFB in that summer. He had full course loads in the Fall of 1996 and the Spring of 1997. He spent June 1-August 15, 1997, at Eglin AFB, FL. He was assigned to Range C64, where the Air Force's Taylor test facility is located. The purpose for this visit was to work directly with range personnel on the reduction of high speed film data from Taylor tests on dense urethane (Adiprene-100). This work was preliminary to our efforts to perform the same data reduction on energetic materials. We engaged in a program of validating the techniques with a known material (OFHC Copper). These techniques will ultimately be applied to N-109, a military explosive of considerable interest to the Air Force and the Navy. Mr. Drinkard finished the requirements for his masters degree in December, 1997. He received his Masters degree in Mechanical Engineering in December of 1997. He planned to pursue a Ph.D. in Metallurgical Engineering and Materials Science beginning in January, 1998. However, the loss of support from this grant changed his mind. In fact, his support in the Fall of 1997 was covered by other University funds in order for him to finish his degree requirements. A copy of his thesis is attached to this report.

BUDGET

The original award from AFOSR was \$164,713 on September 1, 1994. The project supported two graduate students, Mr. Sandor Augustus and Mr. Jeffrey A. Drinkard. There are no outstanding commitments. The balance in the account, as of July 31, 1997, was \$102,916.42.

DISCUSSION

The work that was accomplished on this project supports an Air Force mission that is essential to our national defense strategy. It provided an educational opportunity for two deserving students that helped to bring us closer to the realization of our goals and objectives. In this context, I regard the project as a success. Mechanical testing, at high strains in the range of strain-rates of interest here, has not been accomplished. Flyer Plate experiments provide strain-rates higher than those mentioned in this report, but only at low strains and at great cost. The Taylor test holds the promise of providing a low cost testing tool that is capable of allowing us access to results for a wide variety of ductile materials. Reducing the data from these experiments is the only obstacle. The support for this project provided by AFOSR helped to contribute to our long-term investment in this area.

ATTACHMENTS